Authors
Vern C Vanderbilt
NASA Ames Research Center
Craig S.T. Daughtry
USDA-ARS
Meredith Kupinski
University of Arizona
Christine Lavella Bradley
University of Arizona
Robert P. Dahlgren
California State University Monterey Bay

NF1676B TN29603

Coming of Age: Polarization as a Probe of Plant Canopy Water Status

We tested the hypothesis that the relative water content (RWC) of the sunlit leaves in a plant canopy may be estimated from polarized canopy imagery. Recently (IGARSS, July 27-31, 2015, Milan, Italy), we reported the results of laboratory polarization measurements of single detached leaves during dry down. We found that RWC was linearly related to the ratio of the reflectance of the interior of the leaf and the leaf transmittance. Here we report application of the laboratory results to estimate RWC for sunlit leaves in a plant canopy.

Using a commercial-off-the-shelf (COTS) Nikon 810 camera with Nikkor 300 mm lens and Polaroid type HN-22 linear polarizer, we photographed in the principle plane a plant canopy displaying a gradient of water stress and collected, at each of multiple points along the gradient, two images, one with the polarization filter oriented for maximum scene response and a second with the filter oriented for minimum scene response. We converted the digital values in the two images to reflectance factor with reference to images of a white, flat, horizontal Spectralon surface. We classified the polarization imagery, identifying reflecting leaves, transmitting leaves, other sunlit vegetation and shadows. For each image pair we normalized the leaf internal reflectance by dividing by the cosine of the angle of incidence of the sunlight on the leaf, selected the leaf maximum transmittance in the scene and divided to obtain the ratio reflectance/transmittance, which we compared with leaf RWC. We determined the leaf relative water content by harvesting a section of leaf and immediately placing it in a sealed container in an ice chest. Later in the laboratory the leaf sample was weighed, rehydrated, weighed, dried and again weighed. RWC was determined using the standard formula.

Our experimental results support our hypothesis, suggesting that the RWC of sunlit leaves in a plant canopy may be estimated from analysis of polarization imagery collected by a COTS camera system. Unlike remotely sensed estimates of canopy equivalent water thickness, our estimates of the RWC of sunlit canopy leaves provide leaf physiological information. We propose RWC estimates based upon sunlit leaves are more

relevant to assessing the water status of a plant canopy than would be RWC estimates based upon large FOV canopy measurements.